Coral Reef Problem Set

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Question 1:

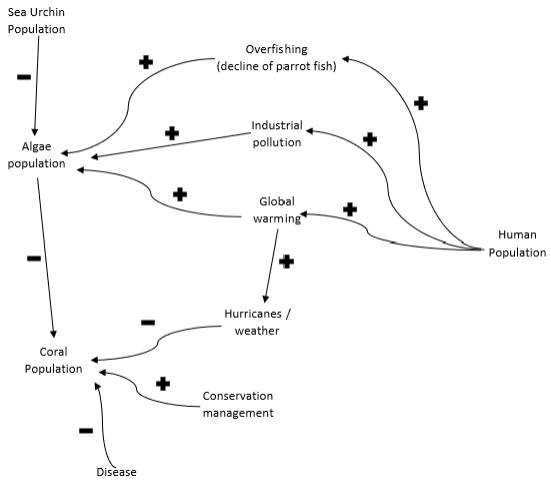


Figure 1: Original Flow Chart

Question 2:

Question 3:

Parameter Description:

- a = competition between macro algae and coral
- *gamma (g)* = competition between algal turf and macroalgae
- r = competition between algal turf and coral
- d = death rate of coral
- s = intrinsic growth rate of parrot fish

In our flow chart, the competition rate a is having a negative impact on Coral but a positive impact on Macroalgae. The competition rate r is having a negative impact on Algal Turf but a positive impact on coral. The competition rate g is having a negative impact on algal turf but a positive impact on Macroalgae. The death rate of coral (d) is having a negative impact on coral populations but a positive impact on algal turf populations as this alters their competition dynamic. If there is less coral coverage the negative impact to algal turf due to competition will be lower. Additionally, *K(C)*, the carrying capacity of the parrotfish population is related to the coral population. As the coral population increases the parrotfish population

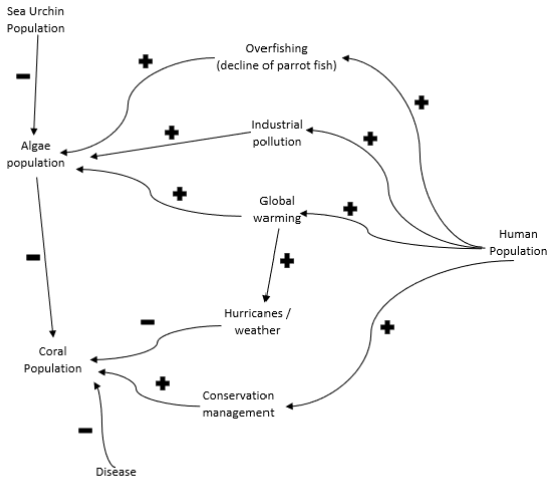


Figure 2: Group Adapted Flow Chart

becomes increasingly limited due to the coral out-competing the algal turf and macroalgae. Alternatively, the intrinsic growth rate of the parrot fish (s) has a positive impact on the parrotfish population. Further, parrotfish are interacting with algal turf and macroalgae in a way that is not specified directly by a parameter. The parrotfish are dependent on the algal turf and macro algae for a food supply, meaning that as these become more scarce the parrot fish population will decline (*scarcity*). Similarly, the higher levels of parrotfish will lead to a decline in macroalgae and algal turf as a result of *predation*.

Questions 4&5:

```
## Loading required package: deSolve
require(deSolve)
```

```
## Loading required package: deSolve
```

```
# Initial values
state <- c(P = 0.5, M = 0.5, TA = 0.5, C = 0.5)
times <- seq(0, 100,by=0.1)

# Parameters
parameters <- c(a = 0.1,g = 0.8, r = 1.0,d = 0.44,s = 0.49)

# Model
reef <- function(t,state,parameters){
  with(as.list(c(state,parameters)),{
       dM <- (a*M*C) - ((P*M)/(M+TA)) + (g*M*TA)
       dC <- (r*TA*C) - (d*C) - (a*M*C)
       dT <- ((P*M)/(M+TA)) - (g*M*TA) - (r*TA*C) + (d*C)
       dP <- s*P*(1 - (P/C))
       list(c(dM, dC, dT, dP))
  })}

# Solve model and plot results
```

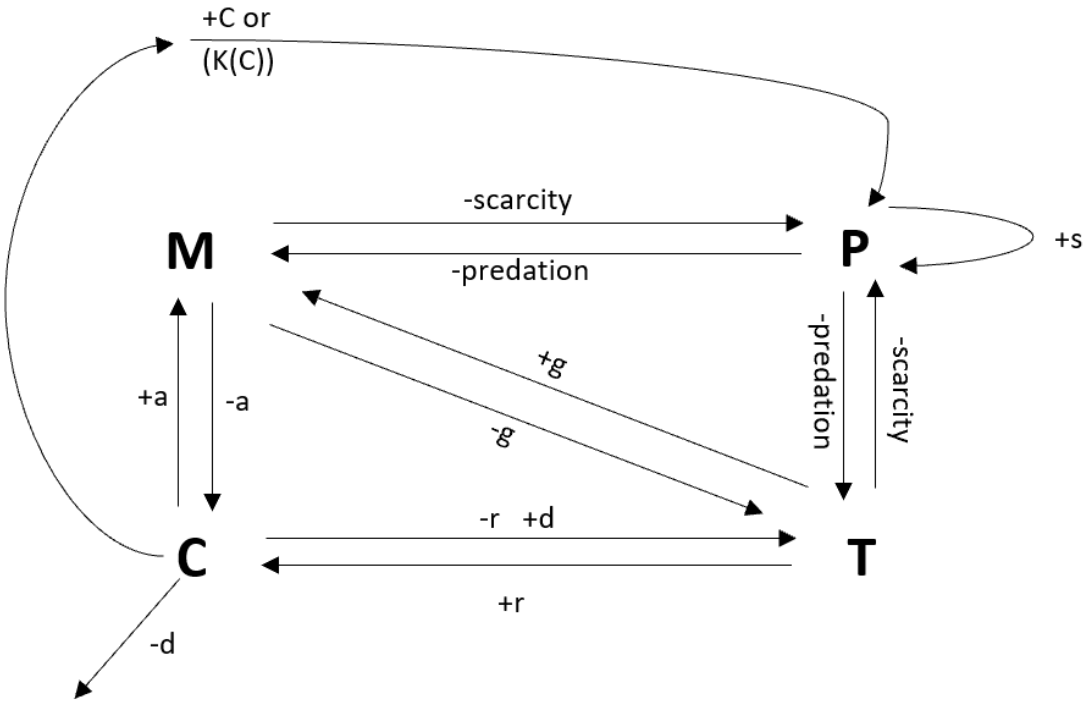
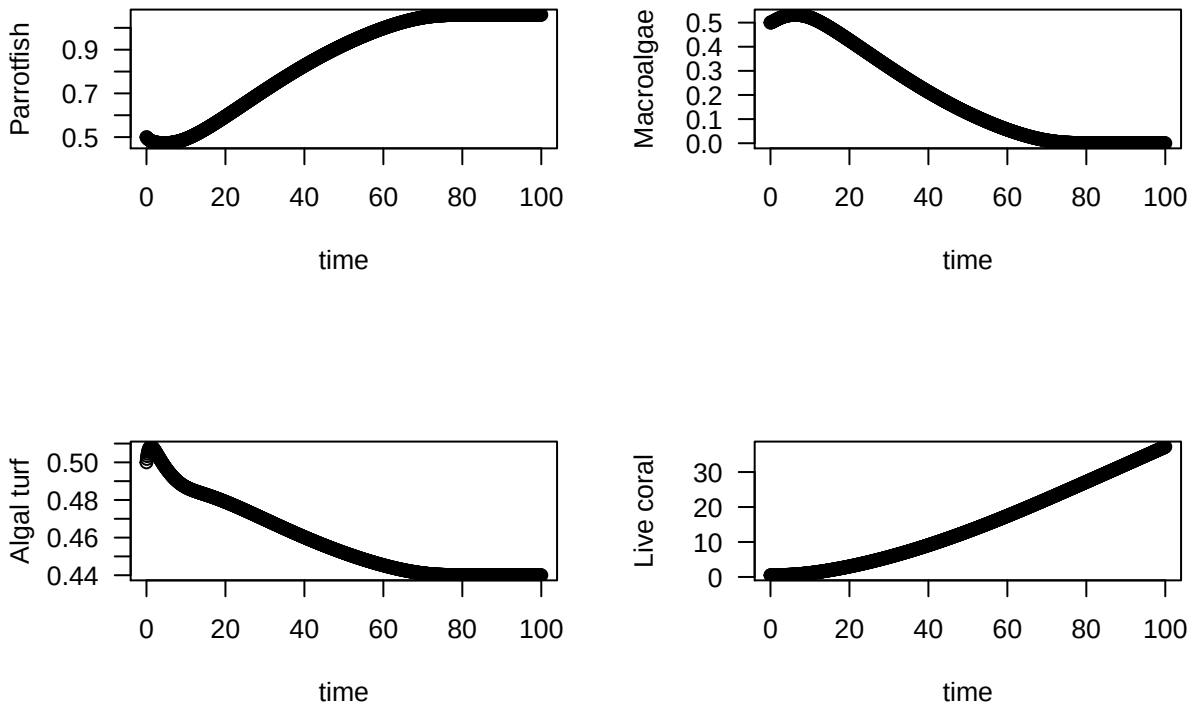


Figure 3: Parrotfish Flow Chart

```
out <- ode(y = state,times=times,func=reef,parms=parameters)
par(mfrow=c(2,2))
plot(out[,1],out[,2],ylab='Parrotfish',xlab='time',las=1)
plot(out[,1],out[,3],ylab='Macroalgae',xlab='time',las=1)
plot(out[,1],out[,4],ylab='Algal turf',xlab='time',las=1)
plot(out[,1],out[,5],ylab='Live coral',xlab='time',las=1)
```



(a) From these models it is apparent that in the long term increase in parrotfish populations ultimately has a positive impact on coral populations. Across time we see that both the parrot fish and coral populations increase while the algal turf and macroalgae but decrease. Eventually, the parrotfish population reaches carrying capacity and levels out. The decline in algal turf also seems to slow suggesting that some baseline level of turf will continue to exist in order to sustain the parrot fish population. Within the 100 year time frame, coral populations do not seem to be slowing in their growth rate, while Macroalgae are virtually non-existent.

(b)

The competition rate between macroalgae and coral (a) seems to be one of the most important parameters as it determines that corals ability to outcompete the macroalgae. Further the predation of parrotfish on both macroalgae and algal turf are crucial as this improves the competitive advantage of the coral. The harmony between the Algal turf population and the parrotfish carrying capacity also ensures that this predation dynamic is persistent across future generations.